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I, JANENE PEISKER, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2004900217 for a patent by MICHAEL JOSEPH MORRISON as filed on 16 January 2004

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Michael Joseph Morrison

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

for the invention entitled:

"Processing apparatus and methods

The invention is described in the following statement:

PROCESSING APPARATUS AND METHODS

FIELD OF THE INVENTION

The present invention relates to processing apparatus and methods and in particular, but not exclusively, the invention relates to an apparatus that may be used to process a wide variety of feed materials by one or more of milling or grinding, mixing, blending, separation, drying and sterilisation. The invention specifically relates to particular processes that may be adopted in the processing of specified feed materials.

BACKGROUND OF THE INVENTION

There are a broad range of situations in which feed materials must be processed in manners resulting in their milling or grinding (terms used herein interchangeably), mixing, blending, separation, drying and sterilisation. For example, many production processes require the use of ground, mixed, blended, dried or sterilised ingredient materials and indeed in recent times it has been recognised that physical characteristics of materials may be advantageous or may in fact alter once the materials are processed to a micro- or nano-particulate diameter. For example solubility, emulsification, colloid forming, light defraction or reflection and absorption properties of materials may be advantageous if the materials are processed to a fine particulate form. For example, the use of a fine particulate form of zinc oxide allows the preparation of transparent zinc oxide containing sun protection creams and fine particulate forms of pharmaceutical agents may exhibit modified pharmacokinetic characteristics such as allowing dermal penetration or more rapid absorption across the gastrointestinal tract.

It is also a focus in this era of increasing environmental concern to minimise the negative environmental impact of industrial and agricultural processes and it has now been demonstrated that processing of feed materials by milling, mixing, blending, separating, drying and sterilisation may provide opportunities to produce useful products or materials from waste materials that would otherwise have been discarded, burned or buried with the

potential for a negative environmental impact. Adoption of processes such as these that result in what otherwise would be considered as waste materials having some economic value are likely to encourage commercial entities to be more responsible with their waste materials.

Not only may milling, mixing, blending, separation, drying and sterilisation processes be of potential utility in waste management and production of fine particulate materials, but such processes may also be useful in the production of powdered foodstuffs, food ingredients or nutritional supplements, production of cosmetics, toiletries and pharmaceuticals, recycling of various materials, paint and dye-stuff manufacture, mineral refining and a broad range of other applications.

Commonly, processes for grinding or milling materials will also produce other process outcomes such as drying and separation, and if more than one feed material is involved, additional outcomes such as mixing and blending may result.

A known form of processing by grinding involves use of a high velocity fluid, particularly air, in a fluid jet pulverising mill (which may also be known as a fluid energy mill) or an anvil mill, wherein particles of a feed material are typically entrained in a vortex of the airstream within a grinding chamber. Highly pressurised air is supplied into the grinding chamber so as to form the vortex and the grinding of particles of feed material is effected by the action of the airstream on the particles and by abrasive contact of the particles with one another and with the sides of the grinding chamber or anvils disposed therein.

In fluid energy or jet mills the autogenous pulverisation of particles is driven by the supplied highly pressurised (that is, compressed) gas or air, and such mills are thus distinguished from hammer mills in which the pulverisation occurs by means of high speed rotating pulverising elements or hammers. Thus fluid energy mills, in contrast to hammer mills, do not include any moving parts. They do, however, involve significantly higher operating expense than hammer mills as the supply of compressed air or gas is a highly expensive medium for supply of energy. Fluid energy mills are also characterised by high

capital costs associated with, for example, the required gas compressors, as well as high running and maintenance costs and a relatively low efficiency of utilisation of the compressed gas to effect pulverisation. Known fluid energy mills are typically in the range of ten times more expensive than hammer mills with respect to the cost of ground product. Consequently the milling of only high value specialty products can justify the costs of utilising a fluid energy mill. The milling in fluid energy mills of commodity products such as coal, cement, minerals, building materials, recycled materials, biomass or waste from food manufacture or other industrial processes generally cannot be conducted at an economically viable cost.

An example of a fluid milling apparatus is disclosed in international patent publication WO 00/56460 that relates to a device comprising an upper annular chamber into which feed material is introduced, and a lower conical chamber. A high velocity vortex flow of compressed air is introduced into the chamber, which gives rise to milling and drying of a feed material.

The present inventor has now devised a processing apparatus and methods for processing feed materials that may offer certain advantages relative to earlier apparatus and methods, such as reduced capital and operating costs and increased processing efficiency.

SUMMARY OF THE INVENTION

According to a preferred embodiment of the present invention there is provided a feed material processing apparatus comprising:

a chamber;

at least one inlet in flow communication to an upper region of the chamber;

a rotor located within the chamber that is rotatable about a substantially vertical axis by a rotation drive;

at least one feature located laterally on the rotor to promote a circulatory flow of feed material and/or gas within the chamber;

at least one outlet in flow communication from a lower region of the chamber.

In a preferred embodiment of the invention the chamber has a substantially circular shape through its horizontal cross section. Preferably the rotor has a substantially circular gross shape through its horizontal cross section and most preferably the rotor is substantially cylindrical in gross shape. Preferably a region of narrowing diameter is provided within the chamber towards a base thereof.

In a preferred embodiment of the invention the at least one feature on a lateral surface of the rotor comprises at least one projection and/or depression. In one embodiment of the invention the at least one depression comprises at least one substantially vertical groove or trough.

In another embodiment the at least one projection comprises at least one spike and/or nodule. Preferably a plurality of spikes and/or nodules form at least one substantially vertical row of spikes and/or nodules. In a particularly preferred embodiment of the invention the at least one projection comprises at least one substantially vertical bar or blade.

In another embodiment of the invention at least one recirculation circuit is provided between an outlet and an inlet to allow return of feed material from a lower region to an upper region of the chamber.

In another embodiment of the invention the at least one inlet comprises a closure and/or a variable aperture. In a further embodiment of the invention the at least one outlet comprises a closure and/or a variable aperture.

In a further aspect of the invention outlets are provided at varying vertical positions of the chamber to allow removal from the chamber of feed material particles of graded size.

In a still further embodiment of the invention a ledge, shelf or screen is provided within the chamber adjacent to the at least one outlet to direct feed material particles to the outlet and/or to promote grading of feed material particle size.

In a further embodiment of the invention a ledge or shelf is provided within the chamber in association with the at least one inlet, onto which feed material can initially be directed.

In a preferred embodiment of the invention the rotation drive comprises a motor drivably engaged to a drive shaft that is in turn drivably engaged to the rotor through a substantially central vertical axis thereof. In a further embodiment a positive pressure scroll is provided within the chamber in association with the drive shaft to substantially prevent ingress of feed material to drive shaft associated bearings.

Preferably the motor is a variable speed electric motor.

According to a still further embodiment of the present invention at least one projection is provided on an upper and/or lower surface of the rotor. In one embodiment the projection on the upper or lower surface of the rotor is at least one spike and/or nodule and preferably a plurality of spikes and/or nodules form at least one row radiating from a centre to a periphery of the upper and/or lower surface.

In a preferred embodiment of the invention the at least one projection on the upper or lower surface of the rotor comprises at least one bar or blade radiating from a centre to a periphery of the upper and/or lower surface.

In a preferred embodiment of the invention the at least one outlet is in flow communication to one or more elements selected from a cyclonic extractor, filter, a bag house, a gas collector and a condenser. Preferably the elements are configured in a manner allowing recovery of one or more of processed feed material, condensed water, condensed oils, gasses and heat. Preferably the apparatus is thermally insulated to minimise heat loss during operation.

In another embodiment of the invention the at least one inlet is configured to allow control of gasses entering the chamber.

According to another preferred embodiment of the present invention there is provided a method of processing a feed material comprising:

introducing the feed material into a chamber of a processing apparatus through at least one inlet that is in flow communication to an upper region of the chamber;

imparting a circulatory flow upon the feed material by rotation about a substantially vertical axis of a rotor comprising at least one laterally located circulatory flow promoting feature;

recovering processed feed material through at least one outlet that is in flow communication from a lower region of the chamber;

wherein the feed material is processed by undergoing at least one of milling, mixing, blending, separation, drying and sterilisation.

According to another embodiment of the present invention there is provided a method of producing a powdered, granulated and/or dried food, food ingredient or nutritional supplement comprising:

introducing a plant or animal derived feed material into a chamber of a processing apparatus through at least one inlet that is in flow communication to an upper region of the chamber;

imparting a circulatory flow upon the feed material by rotation about a substantially vertical axis of a rotor comprising at least one laterally located circulatory flow promoting feature;

recovering a powdered, granulated or dried food, food ingredient or nutritional supplement through at least one outlet that is in flow communication from a lower region of the chamber.

Preferably the plant derived feed material comprises sap, wood, plant leaves, seeds, roots, shoots, stems, branches, bark, fruit and/or components thereof. Preferably the animal derived feed material comprises meat, offal, eggs, milk, blood, skin, hair, fur and/or shell.

In another preferred embodiment the plant or animal derived feed material comprises one or more biproducts from food or beverage processing or production, such as biproducts from fermentation, brewing, culturing, baking, cooking or the like.

According to another embodiment of the invention there is provided a method of processing a waste material comprising:

introducing the waste material into a chamber of a processing apparatus through at least one inlet that is in flow communication to an upper region of the chamber;

imparting a circulatory flow upon the waste material by rotation about a substantially vertical axis of a rotor comprising at least one laterally located circulatory flow promoting feature;

recovering the processed waste material through at least one outlet that is in flow communication from a lower region of the chamber;

wherein the waste material is processed by undergoing at least one of milling, mixing, blending, separation, drying and sterilisation.

Preferably, the waste material comprises treated or untreated sewerage, animal manure, paper, glass, offal, animal skin, shell, fur, hair or feathers, cementatious material, rock, bitumen, hydrocarbon material, plastics, polymers, oils or fats or a biproduct from mineral processing or extraction.

According to a further embodiment of the present invention there is provided a method for water purification comprising:

introducing water to be purified into a chamber of a processing apparatus through at least one inlet that is in flow communication to an upper region of the chamber;

imparting a circulatory flow upon the water to be purified by rotation about a substantially vertical axis of a rotor comprising at least one laterally located circulatory flow promoting feature;

separately recovering impurities and substantially purified water that have exited the chamber through at least one outlet that is in flow communication from a lower region of the chamber.

Preferably the water to be purified is sea water.

According to another preferred embodiment of the invention there is provided a method of milling a solid feed material to produce a granulated or powdered material, comprising:

introducing the feed material into a chamber of a processing apparatus through at least one inlet that is in flow communication to an upper region of the chamber;

imparting a circulatory flow upon the feed material by rotation about a substantially vertical axis of a rotor comprising at least one circulatory flow promoting feature on a lateral surface thereof;

recovering a granulated or powdered material through at least one outlet that is in flow communication from a lower region of the chamber.

Preferably the solid feed material is glass, wood, grain husks or chaff, concrete, rock, bitumen, plastics, polymer material or minerals.

BRIEF DESCRIPTION OF THE FIGURES

The present invention will be described further and by way of example only, with reference to Fig. 1 which shows a schematic representation of the processing apparatus.

DETAILED DESCRIPTION OF THE INVENTION

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will

be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that that prior art forms part of the common general knowledge in Australia.

In one broad aspect of the invention there is provided a feed material processing apparatus which comprises a chamber having at least one inlet that is in flow communication to an upper region of the chamber and a rotor located within the chamber that is rotatable about a substantially vertical axis, by a rotation drive. There is also provided on a lateral surface of the rotor at least one feature that promotes a circulatory flow of feed material and/or gas within the chamber, and at least one outlet that is in flow communication from a lower region of the chamber.

The present inventor has demonstrated that an apparatus of this type can be used to process a broad variety of feed materials such as by milling, mixing, blending, separation, drying and/or sterilisation. Throughout this specification and claims these processing outcomes will be referred to under the general description of "processing" or "processors".

Without wishing to be bound by theory it is believed by the present inventor that the processing capabilities demonstrated by the apparatus of the invention result from subjecting the feed material within the chamber to a circulating flow, with the result that discreet units of the feed material are subjected to repeated collisions with other discreet units and with interior surfaces of the chamber and rotor. Furthermore, however, discreet units of the feed material are believed not only to travel in a circulatory flow, but that these discrete units develop an orbital rotation, with the result that the discreet units of feed material have a high kinetic energy so that collisions of discreet feed material units involve sufficient energy to break chemical bonds of the feed materials, with the result that the feed material is ground or milled to a particulate form in a highly efficient and rapid manner. Furthermore, by virtue of the centrifugal force to which feed particles are

subjected, larger particles are distributed towards the chamber wall in the course of their circulatory flow and are more rapidly driven toward a lower region of the chamber than smaller particles. These particle path characteristics allow the possibility of controlling particle size of the processed material.

It is also believed that as a result of the circulatory flow of feed material collisions between discreet units or particles does not give rise to undue disruption to particle flow direction, enabling energy within the processing system to be maintained and processing to be extremely rapid. Although temperatures of feed materials are elevated to high levels during processing, the feed materials are exposed to these high temperatures for only brief time periods. Without wishing to be bound by theory it is believed that this characteristic has the result that while the temperatures are sufficient to allow sterilisation by rupturing of living cells to inactivate bacteria or other microorganisms, the limited time of exposure to elevated temperature is generally not sufficient to degrade unstable chemical compounds within the feed materials.

In view of this explanation of the principles in operation during processing using the apparatus of the present invention it can readily be seen that the processing that may be conducted utilising the apparatus includes milling, mixing, blending, separation, drying and sterilisation of feed material. In this context "feed material" is used generally to refer to the wide variety of materials that may be subjected to processing utilising the invention. These feed materials may take a variety of physical forms including solids and liquids, slurries, suspensions and solutions. Some specific, non-exhaustive, examples of feed materials that may be processed according to the invention include plant or animal derived feed materials such as plant sap, leaves, wood, seeds, roots, shoots, stems, branches, bark, fruit and/or components thereof, meat, blood, offal (including animal internal organs and bone), skin, membrane, shell, fur, hair or feathers; waste materials such as treated or untreated sewerage, animal manure, paper, glass, cementatious material, rock, bitumen, hydrocarbon material, plastics, polymers, oils or fats and biproducts from mineral processing and extraction; water requiring purification such as contaminated water resulting from industrial or cleaning processes or salty ground or sea water. The feed

materials may also include solid materials such as glass, wood, grain husks or chaff, concrete, rock, bitumen, plastics or polymer material that is to be milled to produce a granulated or powdered product.

Some specific areas in which the apparatus and methods of the invention are applicable include: the production of powdered material from fruit or fruit pulp or from other plant material (e.g. wheat grass) that may be used as a food or nutritional supplement; the processing of poultry industry by-products such as milling and drying manure to form a powdered material that may be used in production of fertiliser, conversion of meat into meat flour, separation of membrane from egg to produce a cartilage powder and calcium carbonate powder and processing of animal carcasses (not only poultry) to produce powdered nutrient source that may be used in fertiliser; grinding, drying to powder and optional mixing of animal feed materials such as cut grasses or straw, corn stems, whey, algae, sea-weed etc.; grinding and extraction of ethanol, water, pigments and/or organic compounds (e.g. resveratrol) from grape marque (waste product from wine production); drying and grinding of pumice; grinding of mineral dross (e.g. from aluminium smelting) to produce powder or granular material that may be useful in production of ceramics; drying and grinding of wood chips or shavings to wood powder; grinding to powder of rice husks for silicon extraction; granulation of polystyrene pieces to small balls; drying and grinding of coal and the de-salination of sea water, for example.

By "milling" it is intended to mean that a grinding process takes place to reduce particle size of the feed material. Solid feed materials may be introduced into the apparatus in large chunks or fragments that through repeated collisions are fractured to much smaller particle size. For example, the material produced through this grinding or milling process may have average particle size (diameter) of between about 100nm to about 10mm, preferably between about 1μm to about 1mm and most preferably between about 5μm to about 100μm, although particle size may be varied in a controlled fashion either within or outside these ranges, as will be further discussed below.

In view of the relatively high temperatures that are generated during processing, the apparatus will cause vaporisation of volatile agents such as water, alcohols such as ethanol, volatile oils or other organic compounds, which can be collected following processing. As a result, the present apparatus can also be used for drying or dehydration of feed materials. Similarly, agents within the feed material may be separated from other agents within the material by virtue of differing physical properties such as phase transition temperatures, solubility, charge, relative particle size magnetic properties, for example.

Furthermore, when two or more feed materials are processed the apparatus may be utilised to effect mixing or blending. Also, in view of the high temperatures during processing the apparatus can be used to effect sterilisation of feed materials. This is of particular relevance in the case of plant or animal derived matter where it may be desirable in order to produce a food or pharmaceutical grade product, to increase storage life, to minimise degradation or to substantially eliminate odours associated with a material, to eliminate or substantially reduce microbial activity within the material.

In the course of processing it may be desirable depending upon the intended product to operate the process with air being introduced into the apparatus, to control the nature of gas introduced (such as conducting processing in a nitrogen, oxygen or other gas atmosphere) or to operate the processing under a vacuum or partial vacuum condition. For example, in the case of readily oxidisable feed materials it may be desirable to conduct the processing in a nitrogen atmosphere. This can readily be achieved utilising the invention, as will be discussed further below.

As shown in Fig. 1 the processing apparatus 1 of the invention comprises a chamber 2 containing a rotor 3, at least one inlet 4 and at least one outlet 5. The chamber itself may take a variety of configurations, but in view of the need to house the rotatable rotor it is desirable that the chamber has a circular horizontal cross sectional shape. While in one embodiment the chamber may be cylindrical in shape with top 6, bottom 7 and side 8 walls it is also possible, for example, for the chamber to taper either to a point or to a bottom wall 7 that is narrower in diameter than the top wall 6.

The chamber 2, the rotor 3 and other major chamber components will preferably be formed of a hard and high temperature tolerant material such as steel or preferably hardened steel or other metal alloys or ceramic material. In view of elevated operating temperatures it is desirable that components of the apparatus that must interact during operation are compatible in that they exhibit similar thermal expansion properties and that they can readily be joined, fused or fixed as necessary. In one preferred embodiment there is provided heating or cooling features in conjunction with the top 6, bottom 7 and/or side 8 walls. For example such heating or cooling features may comprises channels or chambers located within or external to the walls, adapted to contain a heating or cooling fluid, which is preferably in fluid communication with a fluid reservoir, the temperature of which is maintained or altered by conventional heating or cooling techniques. The heating or cooling fluid may for example comprise air, gas (e.g. hydrofluorocarbon gas), oil or water.

The chamber 2 top 6, bottom 7 and side 8 walls may be formed or moulded by a variety of known techniques and may comprise a single unit or may be formed from a number of component parts that are either fused or preferably removably fastenable to form the chamber 2. In one preferred embodiment the side wall 8 comprises a unitary component that is then fixed or releasably fastened to separate top 6 and bottom 7 walls. For example fixing of the components that together form the chamber 2 may be by welding, and releasable fastening of components may be effected using bolts, clamps, clips or other suitable releasable fastening mechanisms. A gasket or gaskets that will tolerate operational temperatures may be utilised to ensure optimal sealing between components.

The at least one inlet 4 to the chamber 2 comprises an opening into an upper region of the chamber 2. By "upper region" it is intended to mean that the at least one inlet 4 is located above the at least one outlet 5. Preferably the at least one inlet 4 is located to allow introduction of feed material into the chamber 2 into an upper third of the chamber 2, and preferably such that the feed material can be introduced above the rotor 3. Similarly, the at least one outlet 5 is located to allow removal of material from a lower region of the

chamber 2. In this context the term "lower region" is intended to convey that it is located below the at least one inlet 4, and preferably within a lower third of the chamber 2.

There may be a plurality of inlets 4 provided. For example there may be provided dedicated inlets 4 for differing feed materials such as for solid and liquid feed materials or for gas that is to be drawn into the chamber 2 during processing, such that by operating closures or variable apertures associated with these inlets 4 the amount or relative amounts of feed materials and gas introduced into the chamber 2 may be controlled.

A plurality of outlets 5 may also be provided and they may for example be positioned at varying heights of the side wall 8 of the chamber 2 or at positions of varying radial displacement in the bottom wall 7 of the chamber 2. Adoption of several outlets 5 in varying positions will enable removal of processed or partially processed feed material at a variety of processing stages or particle sizes. In an important preferred embodiment of the invention at least one of the outlets 5 forms, in conjunction with at least one of the inlets 4, a recirculation circuit 9, allowing processed or partially processed feed material to be removed from a lower region of the chamber 2 and returned to an upper region of the chamber 2, for further processing. For example tubing or pipes that may be releasably fixed about the inlets 4 and/or outlets 5 may allow for flow communication of feed materials or processed or partially processed material from the outlets 5 to the inlets 4 of the recirculation circuit 9.

In order to direct processed or partially processed feed material towards the at least one outlet 5 and/or to assist or promote in the grading of processed or partially processed feed material by particle size, there is provided in one embodiment of the invention a ledge, shelf or screen 15 adjacent to or in association with one or more of the outlets 5. The ledge, shelf or screen 15 may be located and configured in such a manner to deflect circulating feed particles towards a particular outlet 5 or may operate by establishing a low pressure zone within the chamber 2 in the vicinity in the outlet 5 to thereby draw processed or partially processed feed material towards and into the outlet 5. In another aspect of the invention a ledge or shelf (not shown) is provided within the chamber in association or

adjacent to at least one of the inlets 4, onto which feed material introduced into the chamber 2 is initially directed. The benefit of providing a ledge or shelf in association with the inlets 4 is to allow acceleration of feed material within the chamber 2 before the feed material contacts the upper surface 10 of the rotor 3. This has the effect of minimising both energy loss associated with introduction of feed material into the chamber 2 and minimising wear and tear on the upper surface 10 of the rotor 3.

Within the chamber 2 a rotor 3 is provided that is rotatable about a substantially vertical axis by a rotation drive 11. The rotor 3 can take a variety of configurations, although it is an important aspect of the invention that at least one feature is located laterally on the rotor to promote a circulatory flow of feed material and/or gas within the chamber 2. For example, in one embodiment the rotor 3 has a square horizontal cross sectional shape such that the features promoting circulatory flow are the corners of this square shape, which when rotating impart a force upon contents of the chamber 2. More commonly, however, the rotor 3 is configured with a substantially circular horizontal cross sectional shape in the form of a cylinder, conical section or cone, but with features provided laterally on the rotor 3 to promote circulatory flow. For example, however, the rotor 3 can also have a horizontal cross section with two or more radiating limbs (not shown), such as opposing limbs at 180°, three limbs spaced at 120°, four limbs spaced at 90°, five limbs spaced at 72°, six limbs spaced at 60°, eight limbs spaced at 45°, ten limbs spaced at 36° or twelve limbs spaced at 30°, for example. Preferably such limbs are evenly spaced, as exemplified above, to ensure balance and stability during rotation. The limbs mentioned in this aspect of the invention may comprise substantially vertically located planar pieces of material fused or connected at or adjacent to a central axis of the rotor. Preferably rotation of the rotor 3 is about a substantially vertical axis such that the force of gravity may be utilised in conjunction with the centrifugal force developed through rotation of the rotor 3, to discriminate between processed or partially processed material on the basis of particle mass.

In other aspects of the invention the feature located laterally on the rotor 3 to promote a circulatory flow within the chamber 2 takes the form of at least one projection and/or

depression. For example, where the feature comprises at least one depression, this may take the form of one or more grooves or troughs (not shown) within a lateral surface of the rotor 3, that may for example be substantially vertical or coaxial with the axis of rotation of the rotor 3 or may, for example, have a helical or spiralling configuration. In other embodiments of the invention the feature can comprise at least one spike and/or nodule (not shown) and preferably a plurality of spikes and/or nodules form at least one row of spikes and/or nodules, that may similarly be substantially vertically located on a lateral surface of the rotor 3, or may have a helical or spiralling configuration. In another embodiment of the invention the feature may comprise at least one bar 13 or blade (not shown) that projects laterally from the rotor 3 and is preferably vertical or coaxial with the axis of rotation of the rotor 3, but may also, for example, take a curved shape that is spiralling or helical in configuration. In the case of the feature comprising at least one row of spikes and/or nodules or a bar 13 or blade, the rotor may be provided with one to many rows, bars 13 or blades, such as 1 to 50, preferably 2 to 20, more preferably 4 to 10 and most preferably 5 to 8 rows, bars 13 or blades, depending upon the scale of the apparatus 1 and the size of the rotor 3.

In another embodiment of the invention the upper surface 10 and/or lower surface 12 of the rotor 3 is/are provided with at least one projection (not shown) such as at least one spike and/or nodule, row of spikes and/or nodules or bar or blade, which in the case of rows of spikes and/or nodules and bars and blades are configured to radiate from the substantially central axis of rotation of the rotor 3. Such projections on upper 10 and/or lower 12 surfaces of the rotor 3 will serve to assist establishment of a circulatory flow within the chamber and may, in the case of projections on the upper surface of the rotor 3, assist in directing feed material introduced into the chamber 2 to the periphery of the chamber 2 during processing.

It should also be understood that relative dimensions of the rotor 3 such as height or depth of lateral features; presence, absence and dimensions of upper or lower projections, vertical height of the rotor 3 itself; and spacing between the lateral edge of the rotor 3 and the side wall 8 of the chamber, may be varied depending upon the desired outcome of feed

material processing. Such variability will influence particle size processing time, operational temperature, drying, mixing, blending, sterilising and separating efficiency and energy consumption, for example. These and other aspects of apparatus 1 configuration can readily be optimised by skilled persons based upon the intended processing outcome.

A rotation drive 11 is provided to rotate the rotor 3 about a substantially vertical axis. The rotation drive 11 comprises a motor that is drivably engaged to a drive shaft that is in turn drivably engaged to the rotor 3 through its substantially vertical axis. For example, the motor may comprise a variable speed electric motor, although other types of motors are equally envisaged. The drive shaft may constitute an axle that is fixed or releasably locked substantially vertically through the centre of the rotor 3, with the axle being driven by the motor via a belt, chain or the like, for example. The drive shaft may penetrate through the top 6 and/or bottom 7 walls depending upon whether the motor or motors are located above and/or below the chamber 2. Preferably the motor is located below the chamber 2, thus allowing an inlet 4 to be located centrally within the top wall 6. In this way the air curtain effect upon feed material introduced into the chamber 2 is minimised.

A clutch may also be conveniently provided to allow disengagement of the motor from the drive shaft, particularly to avoid damage to the apparatus 1 in the case where rotation of the rotor 3 is restricted, or jamming occurs. In conjunction with the rotor 3 a positive pressure scroll (not shown) or similar device may also be provided to substantially prevent feed material or processed or partially processed feed material entering the housing of the drive shaft or associated bearings.

For further processing of materials following their exit from the chamber via the at least one outlet 5, at least one of the outlets 5 may be configured in flow communication with further element such as a cyclonic extractor 14, filter (not shown), a bag house 16, a gas collector 17 and a condenser 18, which may for example be connected in sequence or in series, depending upon the desired processing product. Preferably all elements of the apparatus 1 including the chamber 2 are thermally insulated to minimise heat loss during processing and preferably the elements are configured in a manner to allow recovery of

processed material, liquid, gas and heat. In a preferred embodiment of the invention the gas utilised during processing can be controlled in both type and amount so that processing may be conducted under conditions of a vacuum or partial vacuum, in air or in specified gaseous atmospheres, such as for example under nitrogen in the situation where the presence of oxygen may give rise to degradation of materials being processed. Preferably also, gasses recovered from the outlet 5 and through any additional processing elements employed can be captured and recirculated through the inlets 4, such that the system is operated in a closed environment without, or at least with minimal, release of gas to the environment.

Another feature of the operation of the apparatus 1 that may readily be optimised depending upon the nature of the feed material to be processed is the speed of rotation of the rotor 3. As a general rule increased rotor 3 rotation speeds will give rise to shorter processing times, greater heat generation and therefore drying efficiency. Increased rotor 3 rotation speeds will also result in reduced average particle size of product material. For example, the rotor 3 may operate at speeds between about 200km/hr and about 1,200km/hr, preferably at speeds between about 300km/hr and about 1,000km/hr and most preferably at speeds between about 500km/hr and about 850km/hr.

In operation of the apparatus 1 the feed material is introduced into the chamber 2 through an inlet 4. Feed material introduced onto an upper surface 10 of the rotor 3 is accelerated by rotation of the rotor and transferred to a lateral region of the chamber 2 by centrifugal force. The feed material is then set in its circulatory flow, with discreet units of the feed material having an orbital rotation applied thereto. As earlier discussed, processing feed material takes place by virtue of collisions of discrete units of the feed material with other discrete units and with the side wall 8 of the chamber 2 and the bars 13 that project laterally from the rotor 3. Higher mass, larger particles within the circulatory flow established in the chamber 2 tend to be located higher in the chamber 2 and towards the side wall 8 whereas smaller, lower mass particles are located lower in the chamber 2 and further inwardly from the side wall 8, due to the presence of the screen 15 that narrows the chamber 2 diameter in a lower region thereof. An outlet 5 located in a lower region of the

chamber 2 is in flow communication with an inlet 4 to form a recirculation circuit 9 allowing removal from a lower region of the chamber 2 of larger particulate matter or incompletely processed feed material, which is reintroduced to an upper region of the chamber 2 for further processing. Completely processed feed material is able to exit the chamber 2 through other outlets 5 and may then be further processed in other elements of the apparatus 1 such as a cyclonic extractor 16, a bag house 17, a gas collector 18 and condenser 19, each of which is in flow communication. Warm dry air that has passed through these elements may then be returned to an inlet 4 via a communication 20 for re-use.

Processing of feed materials of specific types such as plant or animal derived feed material, waste materials, water requiring purification or solid feed materials may be achieved under operating conditions optimised in respect of the desired product.

The invention will now be described further with reference to the following non-limiting examples:

EXAMPLES

Example 1 - Processing of grape marque

Grape marque constitutes the remnants left after the juice has been squeezed for the wine making process. The grape marque contains seeds, skin and remnants of flesh as well as some small percentage of juice that has not been squeezed. The grape marque has in the past presented many problems in that it is a waste product and generally there is a cost in finding a suitable means for disposal of this material.

There are many valuable products within grape marque, which are generally costly to separate. For example, the seeds contain oil but to extract the oil the seeds need to be subjected to a complicated separation process. There are also compounds within the marque including secondary metabolites such as resveratrol that may have medicinal

properties, such as for treating cancer. There are food-colouring and flavouring agents within the marque, all of which require expensive extraction processes.

By utilising the apparatus of the invention it is possible to improve the processing of grape marque to capture many of the valuable components within the marque and turn them into a profitable series of products, such as active compounds and extracts, vinegar, health wine, cooking wine, cosmetics, nutrient supplements and grape seed oil.

Running the marque through the apparatus of the invention results in separation of the alcohol and water whilst at the same time pulverizing the entire solids in the marque, including the seeds. By crushing the seeds the oils are released and can be collected or left in with the grape mark residue (it is important to note that the grape seed oxidizes quickly once the seed is opened and this can give rise to spoiling of the marque residue if the process is delayed).

Health wines or vinegars are produced by mixing the liquid marque, which includes the must. Seed included in this material adds more starch and can thus be re-fermented to produce vinegar or a healthy wine, containing health promoting compounds and flavouring agents that are normally difficult to extract from the marque. This type of wine or vinegar attracts a high retail value.

This processing of wine marque offers an important breakthrough as it overcomes a significant environmental waste problem associated with the wine industry, at the same time as producing a profit centre.

In carrying out this process it is preferred to grind the wet grape marque to a fine powder without undue heating of the material, at the same time separating out the alcohol and water in such a way that substantially all of the liquid is retained and collected. This is achieved by running the mark through the apparatus of the invention wherein the rotor is spun preferably at above two hundred miles per hour, and more preferably at 500 miles per hour or more.

This processing causes the material to break down into fine particles, which along with vaporised moisture exit the machine and are separated in a separator consisting of two or more pressure sealed containers the first of which is a vortex separator with material entering the side port at a tangential angle, and with the material exiting through a similar diameter exit hole in the centre of the lid to the container which has part of the exit tube descending into the space in the drum. A relatively dry solid product is distributed in the first drum and the steam including the alcohol is transported to the second drum. The second drum has a filter bag mounted into the lid and the steam ascends through this bag ensuring that very little solid matter escapes with the steam. The steam is then caught in a tube and is condensed and collected. The dry air may be returned through the inlet along with new gape mark, which assists to conserve heat and minimise loss of material, to the atmosphere.

The advantage of separating the liquid is that it can be controlled in many different ways when recombining with the must or fine material. For example the oil can be removed from powder before recombining. If an extended fermentation is to take place the solid material is broken up so fine that new material is available for the yeast to act upon.

The remnant must has value as a skin treatment because it is so fine that agents can be absorbed through the skin. This material can be incorporated in skin treatment creams. It is ideal for this material to below 100 micron and preferably below 30 micron in diameter. It is preferred to reduce water content of the must below 5% moisture and preferably below 2% moisture.

<u>Example 2</u> – Processing of poultry manure

Poultry manure has been widely recognised as providing a useful nutrient source to promote plant growth. Normally the manure contains about 60% moisture when it is collected from the chicken house. It is preferred to reduce that moisture content as soon as possible to minimise bacterial activity in the manure. Once the moisture is removed the

product is preserved to a major extent. Wet manure produces a very strong odour and is unpleasant if stored in a public.

When the manure is processed in the apparatus of the invention, the material is both ground and dried simultaneously to result in a product that can be stored for long period in sealed bags. When exposed to water a liquid manure is produced, sediment of which can be separated. The fertiliser is suitable to be diluted and dispensed through most irrigation and spraying systems.

Samples of manure processed with the apparatus of the invention when operating at 50 hz produced a material below 100 micron, with an average particle diameter of around 50 micron and a moisture content below 1.5% moisture.

Example 3 – Processing of Pumice

Pumice is an aerated volcanic glass that is pozzolanic and can be used as a cement additive to produce high strength concrete if the material is ground to particles of average diameter preferably below 5 micron.

Grinding in the apparatus according to the invention cost effectively dries and grinds the pumice in a single step. A sample of pumice pieces was ground at 50hz to produce a product under 7 micron, with an average particle diameter of 2 micron and a moisture level below 1%, which was suitable for use as a cement additive.

It is to be understood that the present invention has been described by way of example only and that modifications and/or alterations thereto that would be obvious to a person skilled in the art based upon the disclosure herein are also considered to fall within the scope and spirit of the invention.

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Michael Joseph Morrison

By DAVIES COLLISON CAVE
Patent Attorneys for the Applicant

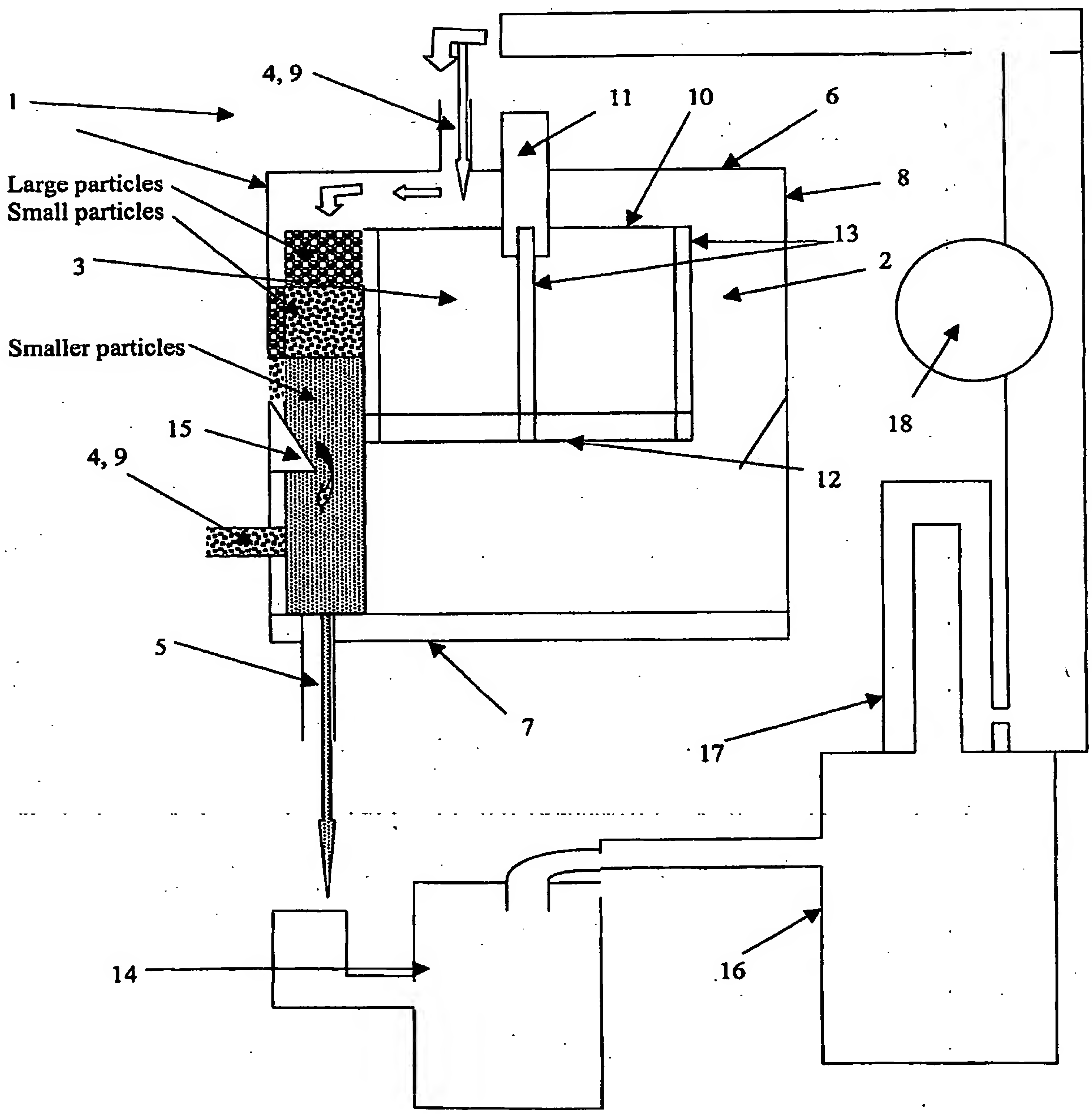
1
4, 9
11
10
6
8
Large particles
Small particles
13
3
2
Smaller particles
18
15
4, 9
12
5
7
17
14
16

Fig 1